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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Tractor Lubrication
and
Lubricants

PUBLISHED MONTHLY BY
THE TEXAS COMPANY, U.S.A.
TEXACO PETROLEUM PRODUCTS

TEXACO TRACTOR LUBRICATION GUIDE

Showing the Correct Grades of Texaco Tractor Lubricants for the Various Types of Gasoline and Kerosene Driven Tractors

The letters opposite each name indicate the Grade of Texaco Tractor Lubricants recommended. "B" indicates Texaco Tractor Oil "B." "C" indicates Texaco Tractoil "C." "D" indicates Texaco Tractoil "D." "H" indicates Texaco Motor Oil Heavy. "M" indicates Texaco Motor Oil Medium. "EH" indicates Texaco Motor Oil Extra Heavy.

MANUFACTURER	MODEL	TRADE NAME	Gasoline			Kerosene		
			Above Frost	Below Frost	Very Cold	Above Frost	Below Frost	Very Cold
Acme Cultivator Co.		Acme, Jr.	D	D	M	D	D	M
Advance Rumely Thresher Co., Inc.	12-20, 16-30	Oil Pull K, H.	C	D	H	C	D	H
	20-40, 30-60	Oil Pull G, S, E.	B	C	H	B	C	H
	15-25, 20-35	Oil Pull L, M.	C	D	H	B	C	H
	15-30	Aultman-Taylor	C	D	H	B	C	H
	22-45, 30-60	Aultman-Taylor	C	D	H	C	D	H
Agrimotor Mfg. Co.		Midwest	EH	H	M	D	EH	H
Allis-Chalmers Mfg. Co.	6-12	General Purpose-Patrol	D	D	M	D	D	M
	15-25, 18-30	A-C, Orchard, Spec. R.M.	C	D	H	B	C	H
	20-35	A-C, Spec. Road	C	D	H	B	C	H
American Farm Mchy. Co.	1½-3	Kinkade (Garden)	D	D	M	D	D	M
American Swiss Magneto Co.	1	Macultivator	H	M	M	..	..	..
Appleton Mfg. Co.	12-20	Appleton	C	D	H	B	C	H
Aro Tractor Co.	3, 6, 8	Aro	C	D	H	..	..	..
Automotive Corp.	12-24	Automotive	C	D	H	B	C	H
Auto-Track Tractor Snyd.	30-50	Auto Track	C	C	H	B	C	H
Avery Co.	8, 12, 14, 18, 25, 40, 45	Avery	B	C	H	B	C	H
	15-30, 20-35, Track Runner	Avery	D	D	H	C	D	H
	25-50, 45-65	Avery	C	D	H	B	C	H
	C	Cultivator C	D	D	M	C	D	M
Bailor Cultivator Co.	A, W, 5-10, 6-12	Bailor 1 & 2 Row Cultivator	D	D	H	C	D	H
Bates Machine & Tractor Co.	15-25, 18-25, 20-25	Steel Mule, H, F, "25"	C	D	H	C	C	H
Bates Machine & Trac. Co.	25-35, 30-40	Steel Mule, G, "40"	C	C	H	..	..	..
Bean Spray Pump Co.		Bean Trackpull	C	D	M	C	D	M
Beeman Tractor Co.	½-4	Beeman, Jr.	D	D	M	..	..	..
	2-4	Beeman, K	C	D	H	..	..	..
Blumberg Motor Mfg. Co.	9-18, 12-24	Blumberg Steady Pull	D	D	H	D	D	H
Bullock Tractor Co.		Bullock	C	D	H	C	D	H
Burn Oil Tractor Co.		Burn Oil	..	..	..	EH	H	H
Cameron Motors Corp.	10	Cameron	C	D	H	C	D	H
Case, J. I. Plow Wks. Co.	15-27, 15	Wallis O, K, O.	C	D	M	C	D	M
Case, J. I. Threshing Machine Co.	12-20, 15-27, 18-32, 22-40, 25-45	Case	C	D	H	C	D	H
	40-72,	Case	C	D	H	B	C	H
Caterpillar Tractor Co.	15, 30, 25-30	Caterpillar 2-5 tons, "30"	C	D	H	C	D	H
	40, 50-60	Caterpillar 10 tons, "40"	C	C	H	B	C	H
Central Tractor Co.	2½-5	Centaur	D	D	H	C	C	H
Clark Tructractor Co.		Tructractor	D	D	M	D	D	M
Cleveland Tractor Co.	9-16, 12-20	Cletrac F, K, W.	C	C	H	B	C	H
Commercial Machine Co.	2½	Comaco	D	D	M	D	D	M
Community Mfg. Co.	10-20	Allen "A"	C	D	H	B	C	H
Dart Truck & Tractor Co.	12-25	Blue "J"	C	D	H	..	..	..
Dayton-Dowd Co.	12-18	Leader "B"	C	D	H	B	C	H
	18-36	Leader "C"	D	D	H	D	D	H
	16-32, 18-35	Leader "N," "GU"	C	C	H	B	C	H
Deere & Co.	15-27, 12-25	John Deere	C	C	H	B	C	H
Dill Tractor Mfg. Co.	26	Dill Harvesting	C	D	H	B	C	H
Dissinger, C. H. A. & Bro. Co.	15-30, 10-20, 25-45, 40-80	Capital	C	C	H	B	C	H
Dodge, H. C., Inc.	½-1	Sprywheel	D	D	H	..	..	..
E. & W. Co.	15	Durable	C	D	H	C	D	H
Eagle Mfg. Co.	13-25, 16-30, 20-40	Eagle H	B	C	H	B	C	H
Electric Wheel Co.	14-28, 16-30, 20-25, 22-40, 25-35	All Work, G, CA, D, E, A	C	D	H	B	C	H
Ellwood Tractor Co.	10-20	Ellwood	C	D	H	B	C	H
Emerson-Brentingham Implement Co.	8-16, 12-20, 16-32	E-B, Cult, Q, AA	C	D	H	C	C	H
Essex Tractor Co.		Essex	C	D	M	C	D	M
Farm Horse Traction Wks.	18-30	Farm Horse	C	C	H	B	C	H
Farquhar A. B. Co. Ltd.	15-25, 18-35 25-50	Farquhar 4-30, 4-40	C	D	H	B	C	H
Federal Foundry Co.	1¼	Federal-Merry Garden	M	M	M	..	..	..
Ford Motor Co.	18	Fordson	C	D	H	C	C	H
Four Drive Tractor Co.	40, 20-35	Fitch "Four Drive" and Model "D"	C	C	H	B	C	H
Fox River Tractor Co.	20-40	Fox	C	D	H	B	C	H
Frick Co.	12-20, 15-30	Frick	C	D	H	C	C	H
General Ordnance Co.	14-28	G. O.	C	D	H	B	C	H
Gilson Mfg. Co.	1-4	Bolens (Garden)	H	M	M	..	..	..
Graham Bros.		Graham	C	D	H	C	C	H
Gray Tractor Co., Inc.	22-40	Gray	C	C	H	B	C	H
	20-36	Gray 1922	C	D	M	..	..	..
Great Western Motors, Inc.	10-15	Fageol	C	D	H	C	D	H
Great Western Tractor Co.		Great Western Sr.	B	C	H	B	C	H
Hart-Parr Co.	12-24, 16-30, 22-40	Hart-Parr, Sp. Hart-Parr	C	D	H	B	C	H

LUBRICATION

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Tractor Lubrication and Lubricants

OF the problems involved in agricultural and industrial production, the handling of materials over comparatively lengthy distances, by means of mobile conveying equipment, and the operation of farming machinery are of outstanding importance. Industry and agriculture, in fact depend for their relative output upon the speed and expedience with which accessory equipment is enabled to function.

From the plow to the towing of a string of trailers around the yard of an industrial plant is seemingly a far-fetched comparison. As we expedite the normal functions of nature, however, in the proper preparation of the soil, so do we expedite natural production, just as we do mechanical production by efficient transference of textile, steel and other products through the average industrial plant.

As a means of attaining the desired results the tractor has developed into perhaps the most salient piece of equipment available today, regardless of the financial status of the operator or the extent of production involved. It has proven its worth in every phase of industry and agriculture, both as a tractor (or puller) and as a pusher of other means of conveyance. In operation it is flexible and economical; it can be handled effectively by the "greenest" type of labor after but little instruction; all it requires is fuel and the right kind of lubricants to keep it operating efficiently over long periods of time.

Tractor duty is heavy. Far more so than that of the average motor truck or automobile. In view of this fact it is the consensus of opinion that *lubrication* is, without a doubt, the most important feature involved in tractor maintenance. Load and speed conditions are so intensive, so continuous, so exacting, that the slightest defect in the lubricating system, the use of improperly refined lubricants, or those unsuited to the service will foster trouble. Eminent engineers have estimated that faulty lubrication is responsible for approximately three-quarters of the tractor difficulties encountered today.

And yet many tractor users are still but half-hearted converts to the importance of lubrication. Too vividly do many of them adhere to their old habits contracted "down on the farm" or in the operation of some second-hand antique in which they chug daily to work. If it runs that is enough. Never mind how much it wears.

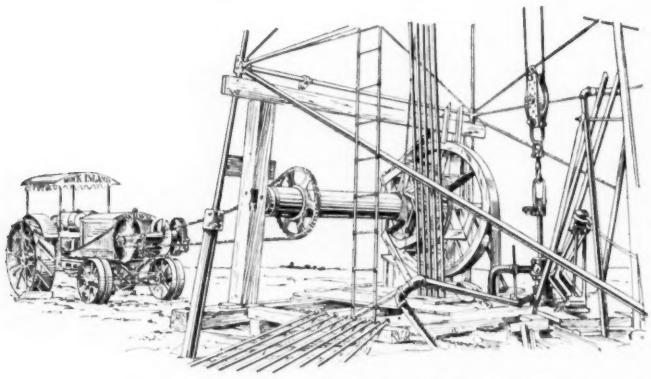
All this may lead some to believe that modern tractor operation and lubrication are problems of great intricacy.

Such is far from being the case. Tractor operation is not a difficult matter. We don't require a college degree to oil or grease one, or to keep it running efficiently and successfully. Nor do we need to be oil experts or mechanical wizards. Rather,—what more of us need is good normal common sense. We must appreciate that successful tractor operation is chiefly based on successful lubrication. The modern tractor is a combination of a multitude of wearing parts; some of these we can see, others are concealed. But they all require lubrication, which cannot be done in a haphazard manner. It must be in most cases a regular or continuous application of the lubricants to the wearing parts during the entire period the tractor is in motion.

To meet requirements tractor builders have made every effort to so design their machines, that lubrication of all wearing parts can be ef-

fectively maintained with the least amount of attention on the part of the operator.

Likewise, the oil industry has done its part in developing tractor lubricants which will be suited to every type of machine and practically every phase of operation.



Courtesy of Rock Island Plow Company

Fig. 1—A tractor winch of the friction transmission type in action. Here it is pulling the tubing in a well. Note winch attachment and chain drives.

The way has therefore been blazed for the tractor owner, and his course should be comparatively easy if he heeds the recommendations of his oil man and the builder of his machine. It is only necessary that he realize the severity of its service, give it a proportional amount of care and attention, purchase grades of lubricants that are refined to stand up under the most abnormal conditions, and apply these as recommended by the builder.

RELATION OF PHYSICAL CHARACTERISTICS OF TRACTOR OILS TO OPERATING CONDITIONS

There are certain definite physical characteristics which require consideration in any discussion of tractor engine oils. It is not fair, however, to deal with them alone, or in but an explanatory manner. To appreciate their real importance requires their consideration in connection with those operating conditions which more or less control their limitations.

In this connection carbon residue, viscosity and pour test are the salient characteristics involved.

Carbon Residue

The formation or development of carbon is probably the most effective guide in the prediction of an oil's utility under continued operation. The power-reducing effects of hard carbon accumulations in the combustion chamber or on the piston heads, valves and valve seats, are known to all. Therefore, every endeavor must be made to obtain an oil which shows as low a carbon residue test as possible, since this is indicative of clean burning, and any carbon that does result should be of a light fluffy nature.

In connection with this matter of carbon formation it is well to remember that such deposits are not strictly pure carbon, nor are they entirely due to decomposition or burning of the oil in a tractor engine. To a more or less extent a considerable percentage will be of a silicious nature, the result of dust-laden air taken in through the carburetor. Dust is abrasive, and in combination with carbonaceous matter from the oil, causes accumulations on cylinder heads, pistons, in piston ring grooves, etc. to not only reduce compression and power generating ability, but also to interfere with free action of the rings, and cause the engine to knock.

It is, therefore, essential, to consider this matter of carbon formation especially from the operating viewpoint—i. e., the relation borne by dirty air. In fact, dirty air, can often be of far more serious consequence as an enemy of effective lubrication, than would a certain degree of unsuitability in an engine oil from the viewpoint of its physical characteristics.

The most effective preventative and insurance is to clean the air prior to its passage into the carburetor and engine. In this way the necessary air for combustion can be effectively freed from dust and dirt. There is considerably more of such foreign matter stirred up where a tractor is used than in average automobile service. Therefore, if the air cleaner is not operating satisfactorily to effectively remove this dust, trouble will be bound to occur, due to the ultimate accumulation of the latter along with gummy, carbonaceous residues from the oil, or perhaps a certain amount of unburned fuel.

Viscosity and Pour Test

Relative to these more distinctly inherent physical characteristics of lubricating oils, it is well to remember that they are of decided importance, due to the extent to which they are contingent upon operating temperatures or fluctuations of the latter. Viscosity, stated in the proper terms, (i. e., Seconds Saybolt at 100 or 210 degrees F. in usual practice) is an indication of the relative fluidity of an oil at the temperature of test.

Pour test, in turn is a measure of the relative sluggishness of the oil at low temperatures, usually in the neighborhood of freezing or below.

In general, the oil must be a sufficiently light bodied product in order to have available the

requisite viscosity to insure immediate flow to the bearings when the engine is started. In this connection it is of interest to note that in agricultural work especially, the majority of the year's operation will take place in the spring and autumn, where it will often be necessary to start the tractor engine under temperatures in the neighborhood of freezing.

In colder weather the use of light-bodied oils may be questioned by some, especially due to the fact that after the engine has come up to speed, the operating temperatures will be practically the same, regardless of atmospheric conditions. Wear, however, of pistons, rings and bearings is more apt to occur to excess on starting than at any other period of operation.

Our problem, therefore, is to insure lubrication whatever the starting temperatures involved, even though the use of a somewhat lighter-bodied oil may reduce seal and compression to a certain extent, give rise to possible fuel loss, and crank case dilution especially when kerosene is being used. Under such conditions the pour test or temperature of congealment should be as low as possible to facilitate immediate flow of the oil to the pump, lubricator or splash elements.

During the summer months, however, tractors will often operate in the intense heat of the sun at continual full load with cooling water at an abnormally high temperature; or, when a tractor is used for threshing, the engine will operate at a standstill and the cooling capacity of the radiator will be somewhat lower. High engine temperatures improve combustion of the fuel, and as a result, crankcase dilution may be reduced to a certain extent. Hence a lighter oil may function properly even in the face of perhaps a certain amount of reduced viscosity.

On the other hand, the possibility of an insufficient film of oil on the major bearings will warrant a certain increase in viscosity over that recommended for cold weather service. Large piston diameters, high clearance, or slow piston travel, will as a general rule call for somewhat heavier oils.

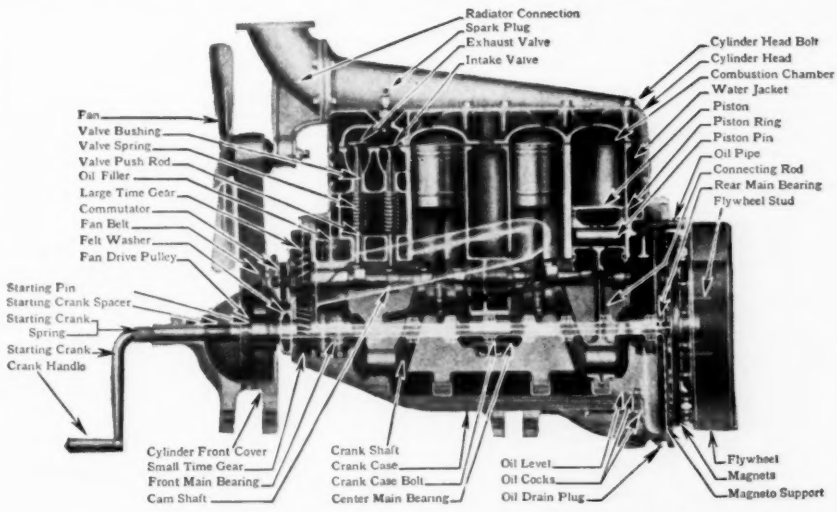
TRACTOR ENGINE OIL REQUIREMENTS

The selection of tractor lubricants which will assure continuous and efficient operation necessitates a clear understanding of the requirements which they must satisfy. From at least a theoretical point of view, the engine will be the most difficult part of the machine to lubricate, though manually, it will frequently be the easiest. Perhaps this is why so many operators often fail to appreciate the extreme importance of proper engine lubrication.

The fact that intensive duty is so often imposed, places very exacting requirements upon both the oil and lubricating system. To meet these conditions, the Petroleum Industry has carried on extensive research and refining investigations to prove that it is possible to refine lubricants from petroleum which will meet working conditions, however exacting, and conform to tractor engine construction, however intricate.

Under average operation the tractor owner, especially in agricultural work, will have practically no means of checking the suitability of his lubricants, or the extent to which effective lubrication is taking place. This is, however, the province of the research laboratory. The tractor owner should not have to worry, any more than the average motorist does, provided he takes care to purchase such products from reputable oil marketers with national reputation and distribution.

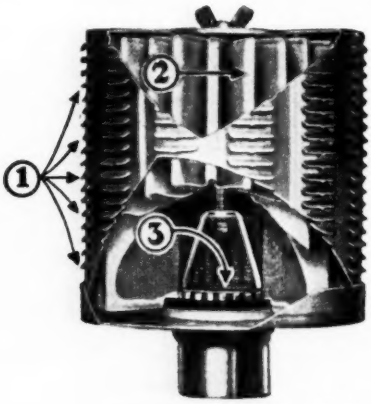
Essentially the trade-mark is his protection, and a veritable insurance of his tractor engine, bearings, gears and chains, against premature deterioration due to abnormal friction. For the



Courtesy of Ford Motor Company

Fig. 2—Sectional view of the Fordson Tractor Engine showing essential working parts. Cylinders and bearings are splash lubricated by oil from the reservoir in the crankcase.

degree of cooperation existing between the tractor builders and the leaders in the petroleum industry has been marked. The latter are continually bending every effort to meet the



Courtesy of Staynew Filter Corporation

Fig. 3—Cutaway view of an air filter adaptable to tractor service. Air enters filter at (1) through openings in outer shell; passes through filtering elements (2) and is discharged to tractor engine at (3).

lubricating requirements of tractor builders. As the latter have developed improvements in tractor design so have the oil refiners kept pace wherever necessary, in producing oils and greases of suitable characteristics and greater refinement. The result has been the extensive tractor lubrication charts of the leading oil companies which are so familiar to all progressive tractor operators.

Certain of the outstanding requirements of tractor engine oils, in particular, are so important and certainly of so much interest that it is well to outline them in brief, as they are viewed by authorities in the field of tractor lubrication. A better understanding of them will enable the progressive tractor operator to discuss the matter of lubrication more intelligently and appreciate its decided importance as related to efficient and economical operation.

In brief, therefore, a tractor engine oil should show:

High lubricating ability or "oiliness."
An ability to withstand heat.
Adequate seal-forming properties.
Low pour test.
The requisite viscosity, and
Development of as little internal friction as possible.

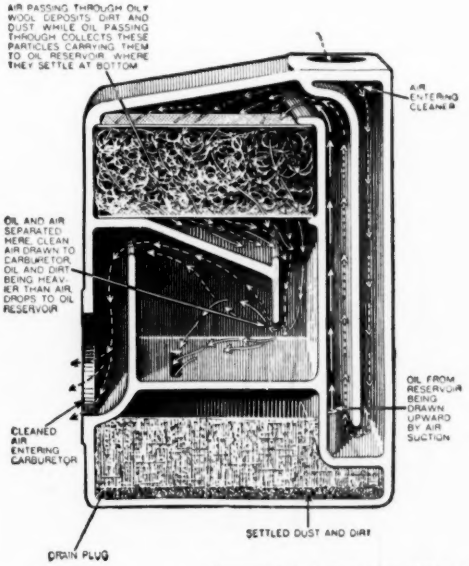
By lubricating ability or "oiliness" is meant the extent to which an oil, in accordance with the viscosity, will be able to form and maintain a suitable lubricating film between the wearing surfaces. The higher this property the greater will be the insurance against burned out bearings, scored cylinders and the occurrence of metallic friction.

The extent to which a tractor engine oil will withstand heat, is in turn an indication of its resistance to decomposition, abnormal loss in viscosity and burning to hard carbon. A good tractor oil should be capable of working under the usually high temperatures of operation without any of these occurring to a marked degree.

Seal-forming properties are important in that such an oil, to be satisfactory, must form and maintain a sufficient seal between the cylinder walls and piston rings to prevent loss of compression, pumping or blow-by.

Low pour test is essential in that it is indicative of the action of the oil in cold weather. The lower the pour test or temperature of relative congealment, the more assurance that a tractor oil will have sufficient fluidity to flow readily throughout the oiling system in cold weather. If undue congealment occurs there will be possibility of at least certain of the bearings being more or less under-lubricated, due to faulty operation of the oil pump or lubricator, or imperfect splashing.

The matter of viscosity is in turn of interest, in that a tractor engine oil, to be satisfactory, must have sufficient body to resist being squeezed out from between any of the wearing parts where pressure may be relatively high, as for example in crankshaft, piston pin and main bearings.


AIR PASSING THROUGH OILY WOOL DEPOSITS DIRT AND DUST WHILE OIL PASSING THROUGH COLLECTS THESE PARTICLES CARRYING THEM TO OIL RESERVOIR WHERE THEY SETTLE AT BOTTOM
AIR ENTERING CLEANER
OIL AND AIR SEPARATED HERE, CLEAN AIR DRAWN TO CARBURETOR, OIL AND DIRT BEING HEAVIER THAN AIR, DROPS TO OIL RESERVOIR
OIL FROM RESERVOIR BEING DRAWN UPWARD BY AIR SUCTION
CLEANED AIR ENTERING CARBURETOR
SETTLED DUST AND DIRT
DRAIN PLUG

Courtesy of J. I. Case Plow Works, Inc.

Fig. 4—Sectional view of the "Wallis" tractor oil air cleaner. Arrows indicate path followed by air from entry to discharge.

And finally, it is well to remember that the development of abnormal internal or molecular friction, that is, friction which occurs between the particles of oil which compose the lubricat-

ing film, may require excessive power consumption in being overcome. Internal or molecular friction is more or less directly related to viscosity, therefore the latter should be an indication of the degree to which it may occur.

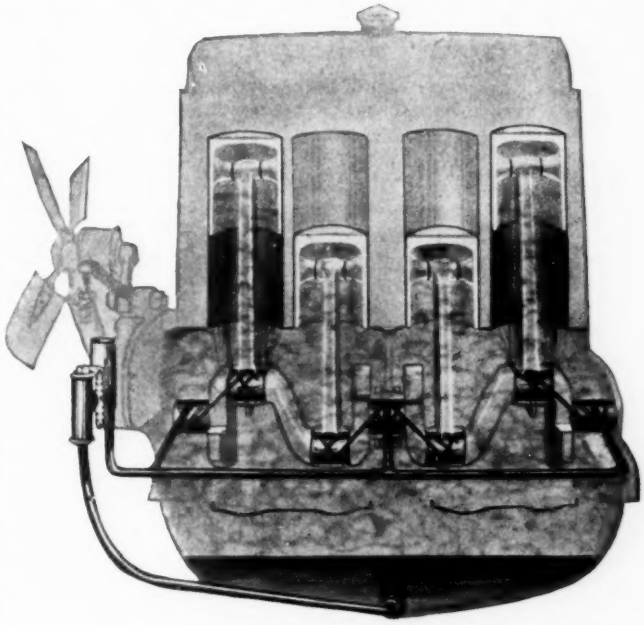
It would be relatively impossible for the operator himself to make any very practical experiments for his own satisfaction. In fact, that would scarcely be necessary for, in reality, a knowledge of the basic oil requirements is all he needs to prove to either his Tractor Builder or Oil Dealer that he knows what he wants. He can then make them prove to him in turn, the reason why any particular grade of oil will be better than another for his specific conditions.

MECHANICAL CONDITIONS INVOLVED

With a knowledge of the requisite qualifications of a tractor engine oil and the extent to which operating conditions must be considered, it is possible to sum up by stating that in selecting a tractor oil we are primarily interested in:

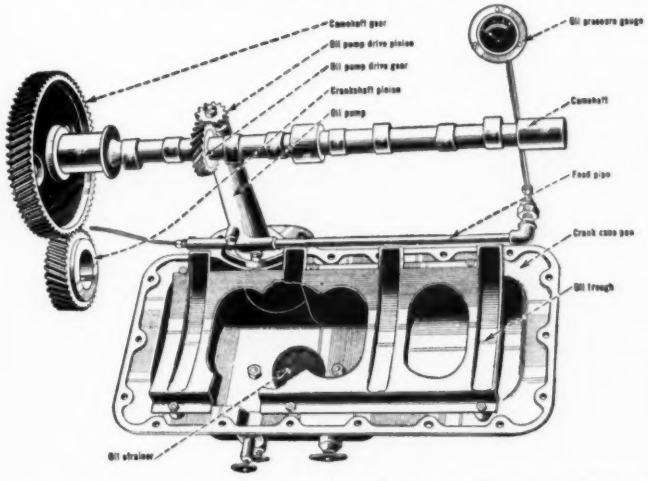
1. How the oil will act on starting in cold weather; that is, whether its pour test is sufficiently low to insure effective flow to all parts of a cold engine or lubricator pump without abnormal internal friction and
2. What its condition will be under operation. This latter is a question of viscosity or body.

It is perfectly evident that the oil must fulfill both of these requirements, otherwise it will be unsatisfactory. Even perfect suitability in either one case or the other, does not recommend its usage in any but exceptional instances, as ultimately trouble will be apt to occur. On the other hand we must temper this consideration with good judgment in certain instances. For example, where mechanical force feed lubricators are used, in cold weather on larger types of engines, an oil must be chosen which, when cold, will be sufficiently fluid to be drawn readily into the pump units. Yet a somewhat heavier oil might possibly be theoretically better if we were to consider engine conditions only.



Courtesy of Minneapolis Steel & Machinery Company

Fig. 6—Side view in phantom of a four-cylinder tractor engine showing oil piping.



Courtesy of International Harvester Company of America

Fig. 5—Details of crankcase pan in one type of tractor showing oil pump, test cocks, pressure gauge, etc.

Therefore, the selection of a tractor oil will essentially be influenced by:

(a) The engine, and

(b) The lubricating system.

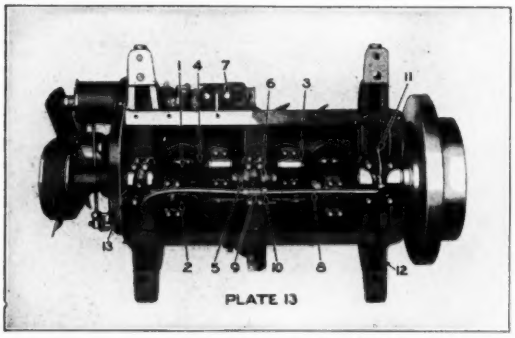
The Tractor Engine

The beneficial results that efficient lubrication of a tractor engine will lead to, are certainly the most interesting and vivid recommendations for the careful selection of tractor oils. They are what we are all ultimately striving for whether our tractor plows snow in zero weather or operates a harvester, etc., in midsummer when the temperature is 100 degrees in the shade. In brief, we want:

1—Maximum power.
2—Minimum crankcase dilution.
3—The utmost fuel economy.

Power Development

Maximum power is attainable only by the use of a tractor engine oil which will not carbonize in the combustion chamber, on the piston head, valves or around piston rings, etc. Hard carbon deposits on valves or seats will cause loss of compression due to uneven seating of the valves. In the combustion chamber such deposits will cause detonation and even pre-ignition. Similar deposits around piston rings or wedged in the grooves will cause sticking of the rings and as a result they will not function properly nor maintain a suitable seal between the piston and cylinder walls. Loss of power and compression will be the direct result.



Courtesy of The Cleveland Tractor Company

Fig. 7—Under-side view of a tractor engine showing oil lines, connecting rods and crankshaft main bearings.

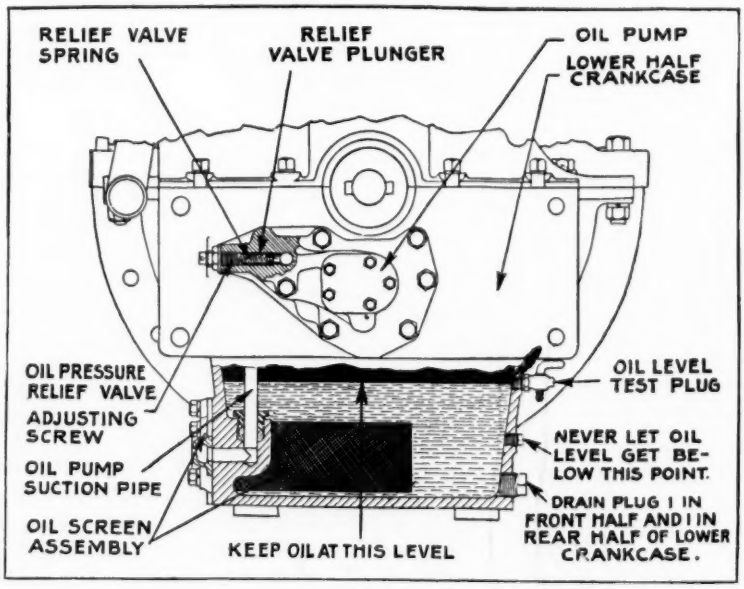
Free movement of the piston rings is the secret of maximum power development in any tractor engine. Their purpose is to compensate for the more or less uneven clearance which must exist between the piston and cylinder, thus forestalling sticking or seizing of the piston under the relatively high temperatures of operation.

As the age of the engine increases, this clearance will be increased due to wear. If the piston rings work freely, and the oil film is of suitable thickness, the clearance will be practically compensated for and little or no loss in compression will result. But a set of sluggish rings due to formation of hard carbon deposits in the piston grooves will immediately cause a certain loss in compression, unless perhaps the oil film is sufficiently thick to fill up the clearance space.

It is advisable, therefore, to always make sure that an oil is being used which will not cause hard carbon deposits. In effect, select a product which will be distilled off entirely into vaporous matter at the higher temperatures of operation, or develop but light fluffy carbon formations which can be blown out by the exhaust. Your Tractor Builder should have tested the oils of all reputable refiners to determine this for you, and many have done so. Where this has been carried out thoroughly, you are safe in taking the Tractor Builder's recommendations. Many Oil Refiners have also made such investigations. In fact, they are often in better position to make lubrication recommendations more intelligently and completely.

Crankcase Dilution

A minimum of crankcase dilution will insure economy in the use of oil, and prevent abnormal wear of bearings due to extreme reductions in viscosity. Generally speaking, crankcase dilution, or the dilution of the engine oil by the fuel, will occur more readily in an engine burning kerosene than one using gasoline. From a gasoline engine viewpoint this subject has been discussed in detail in **Lubrication** for September, 1923, and July, 1925, in articles on "Why Automobile Oils Must Be Periodically Changed," and "Some Recent Developments in Automotive Engine Lubrication."

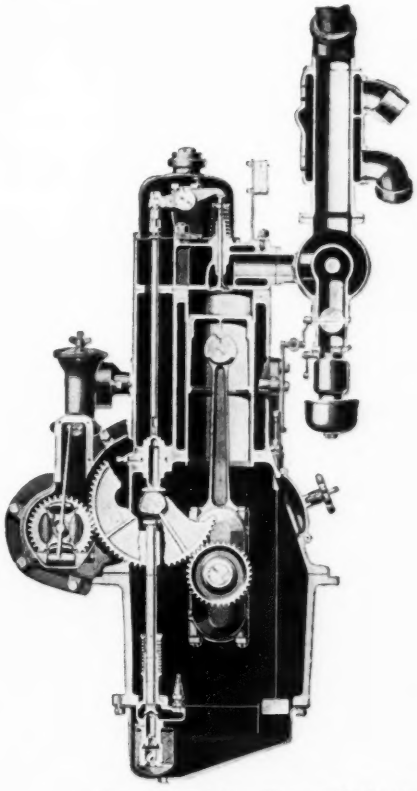

RELIEF VALVE SPRING
RELIEF VALVE PLUNGER
OIL PUMP
LOWER HALF CRANKCASE
OIL PRESSURE RELIEF VALVE ADJUSTING SCREW
OIL PUMP SUCTION PIPE
OIL SCREEN ASSEMBLY
KEEP OIL AT THIS LEVEL
OIL LEVEL TEST PLUG
NEVER LET OIL LEVEL GET BELOW THIS POINT.
DRAIN PLUG 1 IN FRONT HALF AND 1 IN REAR HALF OF LOWER CRANKCASE.

Courtesy of Caterpillar Tractor Company

Fig. 8—Base of a tractor engine showing in detail the essential parts of the lubricating system, and oil level and drain points.

The same discussion will apply to the kerosene engine but we must remember that vaporization of kerosene is very apt to be less complete, and therefore crankcase dilution will be more rapid. On the other hand, the fact that dilution has occurred is no indication that the lubricating value of the oil has been lowered. This matter was treated in detail in the above articles.

Many tractors today use kerosene as fuel for reasons of economy, although they require gasoline for starting. Kerosene will usually not burn as completely as gasoline due to the presence of more or less so-called heavy ends or fractions of low volatility which remain unvaporized. Of course, under higher engine temperatures more of these hydrocarbon fractions will be vaporized and burned during the combustion stroke.

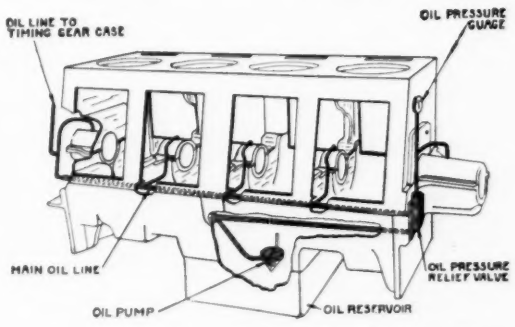


Courtesy of J. I. Case Threshing Machine Company

Fig. 9—End view of a tractor engine showing lubricating pump, method of operation, strainer and oil level float.

This will never occur to completion, however, and a certain amount of fuel will always find its way into the crankcase either by leakage past the piston rings or by being absorbed by the film of lubricant on the cylinder walls. Either is a direct cause of dilution of the oil in the crankcase, and this is progressive up to a certain point where the viscosity of the oil will have reached a state of equilibrium, depending upon the operating temperature of the engine.

To a certain extent the possibility of crankcase dilution would seem to be lower in a tractor engine than in the average automobile engine on account of the fact that higher operating



Courtesy of Caterpillar Tractor Company

Fig. 10—Diagrammatic view of a tractor engine lubricating system, of the forced-feed type. A rotary gear pump in the reservoir delivers the oil to the various wearing elements.

temperatures are involved. The lower volatility of kerosene, however, usually defeats this possibility. In fact, instances are known where kerosene entered the crankcase faster than the oil was consumed, overflows being necessary to prevent the accumulation of too much of this mixture in the crankcase.

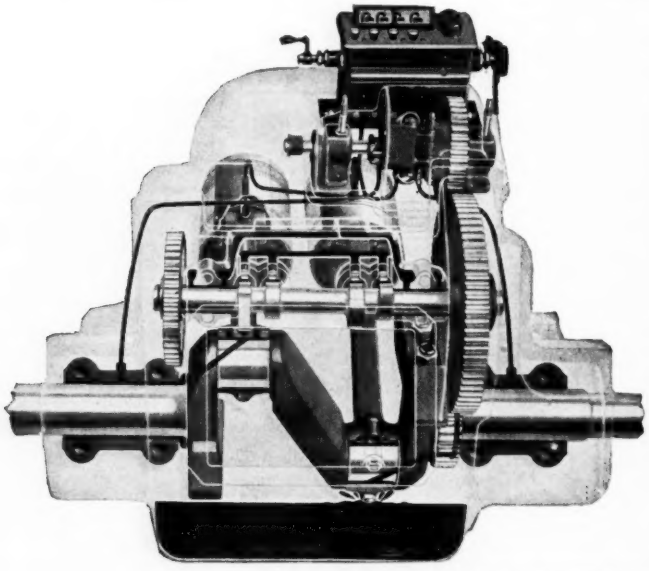
It is a simple matter to make a rough test on dilution by drawing off a sample of oil from the crankcase into a bottle and comparing it with a similar bottle full of fresh oil, being sure that both are at the same temperature. By rapidly and simultaneously inverting both bottles, the relative rise of air bubbles will indicate whether the used oil has been diluted to any extent. The more rapidly the bubbles in the latter sample rise, as compared with those in the fresh oil the lower will be its viscosity.

Fuel Economy

Attainment of proper fuel economy will be directly related to the matter of compression and crankcase dilution. If compression is poor and the valves and piston rings are not at fault, that is, if the lubricating film on the cylinder walls is not furnishing the requisite seal due to use of an oil which is unable to withstand the pressure of compression and explosion, or if carbon formations are interfering with the free action of the piston rings, a certain amount of the charge will blow past the piston on the compression stroke, as will also some of the gases during the combustion stroke. Blow-by of this nature will lead directly to crankcase dilution and of course, loss of fuel for the fuel that enters the crankcase and dilutes the oil has

little or no further opportunity of producing power.

As crankcase dilution continues, additional power may be consumed especially if bearings or other wearing parts become under-lubricated due to abnormal reduction in viscosity, and metal to metal contact occurs.



Courtesy of Advance-Rumely Thresher Company, Inc.

Fig. 11—Lubrication details of a two-cylinder tractor engine using a Madison-Kipp mechanical force-feed lubricator. Note path of oil travel by heavy black lines.

Valve and piston ring adjustments are assumed as being correct simply for the purpose of bringing out the other factors involved. These are mechanical details which will usually be maintained in proper operating condition by the progressive tractor owner.

To a certain extent, lack of power, suitable compression and fuel economy, or an excess of crankcase dilution will be manifested to the tractor owner over long-run operation, both by the productive ability of his machine, and his fuel and lubricating oil bills. In fact it is not a relatively difficult matter to carry on comparative running tests on any number of grades of oil, by simply taking proper records of fuel and oil consumption, mileage covered (over of course, similar territory), and making regular inspections of the cylinder head, piston and valves for carbonization.

Provided operating conditions are maintained as nearly alike as possible and the crankcase or lubricating system is properly cleaned and drained with a suitable light engine slushing oil prior to the introduction of any new or different grade of tractor engine oil, any records as specified above can be relied upon to give a good comparison of the relative ability of any number of oils to meet the requirements outlined.

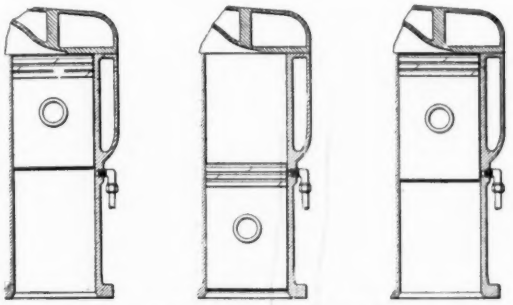
Engine Lubricating Systems

Having laid so much stress on compression, piston ring seal and crankcase dilution in discussing engine conditions, we naturally lead up to the query: Why not so design Tractor engine oiling systems as to obviate the losses involved as much as possible?

In a word, this is more than ever the ambition of automotive engineers throughout the world. To this end they have used the mechanical force-feed lubricator, the circulating splash system and the full pressure method of lubrication, even including certain of their combinations. The outstanding developments as brought out in **Lubrication** for July, 1925, will be of interest in this regard.

Circulating Oiling Systems

Circulating full pressure, force-feed, or splash oiling systems are installed by many tractor builders. In effect, an effort is being made to standardize tractor construction in the same manner as the automobile has been standardized; hence the tendency of many builders to use methods of lubrication which have been proven adaptable to the automobile engine up to the present time.



Courtesy of Madison-Kipp Corp'tion and Society of Automotive Engineers

Fig. 12—Method of oil application to cylinders by a mechanical force-feed lubricator. Note point of oil injection to right of cylinders. Left-hand view shows a short piston at top of the dead-center; central and right-hand views show a long piston at bottom and top positions. With this latter piston oil-injection point is never uncovered.

The full pressure system of lubrication is preferred by many in view of the fact that a sufficient amount of oil is assured to all moving parts when the engine is running, and no oil is wasted or discarded until its lubricating value has been so reduced as to render this advisable.

In this system it is hardly necessary to state

that oil is forced to the various engine parts to be lubricated under a controllable pressure by means of a suitable pump (usually of the geared type), which is located in the oil reservoir.

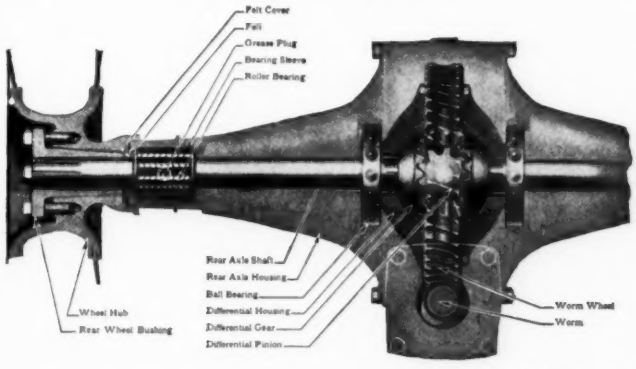
Splash lubrication by oil from the reservoir in the crankcase as extensively used on many tractors is a somewhat simpler means of bringing about effective lubrication of engine parts, the oil circulating back to the reservoir by gravity for re-usage. From the viewpoint of engine hours operated this oil should be changed every 40 to 50 hours when using gasoline as fuel; or every 30 to 40 hours when using kerosene.

In other respects lubrication of tractor engines by circulated oil feed in some form or other is so akin to that of the automobile engine that further description of systems, etc., is unnecessary.

Mechanical Force-Feed Lubricators

Mechanical force-feed lubricators of the external types which are designed to feed fresh oil drop-by-drop to the cylinders and main bearings, have been used more or less extensively in tractor practice for many years.

Such devices surmount the difficulty of crankcase dilution by furnishing a supply of fresh oil constantly to each bearing and cylinder via individual plunger pumps and oil ducts. This method of lubrication is very similar to that so commonly employed on many types of reciprocating steam engines, etc., today. The oil flow is absolutely controlled in its intensity, as well as in its starting and stopping by the engine, since the lubricator pumps are driven directly by the latter.

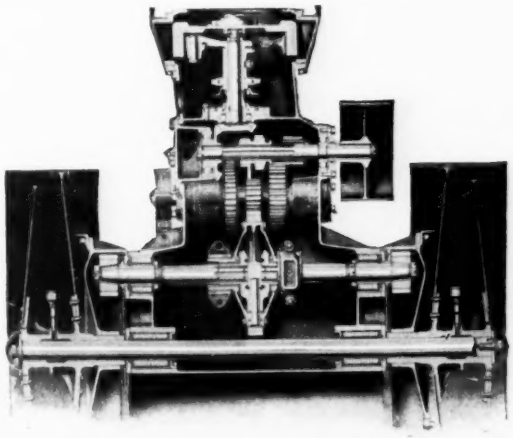


Courtesy of Ford Motor Company

Fig. 13—A tractor rear axle and wheel assembly showing gear and bearing details. Note that both ball and roller bearings are used on this tractor.

To supply fresh oil to the bearings when the engine is not running, the mechanical lubricator is usually provided with a hand crank. This should always be operated prior to starting in order to insure that sufficient oil will have reached the bearings to maintain lubrication until the engine has put the lubricator pumps in operation.

The question of oil flow or travel through exposed piping in cold weather is often raised when considering the proper viscosity for winter service. The travel of oil through such exposed piping, however, as the mechanical lubricator will involve, does not depend on viscosity. An efficient oil pump will even force grease through such piping against pressures of approximately 1,000 pounds per square inch. It is the drawing in or suction of the lubricant into the pump chambers which involves the viscosity or fluidity of the oil, as is true of any pump in any type of oiling system.



Courtesy of Allis-Chalmers Manufacturing Company

Fig. 14—Sectional view of a tractor transmission wherein ball and roller bearings as well as plain babbitted bearings are involved. Note grease cups on wheel bearings.

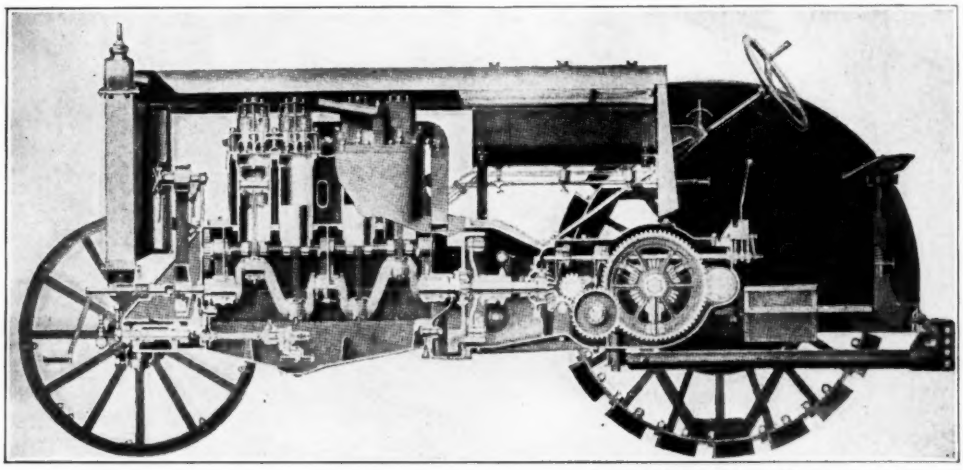
The advantage claimed for the external mechanical force-feed lubricator, is that a regular, predetermined supply of clean fresh oil, free from fuel contamination and dust, is furnished to all cylinders and bearings. As a result the effects of crankcase dilution are eliminated since the oil which drains from these wearing parts is not used again as an engine lubricant. Oftentimes it is used, however, for rough machine lubrication as on gearing, etc. Otherwise it is thrown away.

The question is frequently raised as to whether this procedure is more wasteful than the discarding of the entire contents of the crankcase every few days when a splash or internal force feed system is employed. The answer is of course, "Yes and No," with certain provisos.

In event of using a suitable oil in an engine where crankcase dilution is not excessive, more oil might be wasted by the external mechanical lubricator. On the other hand, the reverse may also often be true where the operator is careless, crankcase dilution excessive, or a low grade of fuel used entailing much priming and the firing of a rich mixture.

TRANSMISSIONS, FINAL DRIVES AND OTHER GEARING

To transmit power from the engine to the rear axle and wheels certain speed change and reduction gears are necessary in the tractor, the same as in the automobile. The transmission located between the engine and the differential, or final drive, in the average machine of this type serves the purpose by means of an arrangement of gears or a frictional transmission device.



Courtesy of Allis-Chalmers Manufacturing Company

Fig. 15—Sectional side view of a modern gas tractor showing relation of engine to transmission. Note tightness of all housings.

From a lubricating point of view the geared transmissions require more consideration, inasmuch as both gear and bearing lubrication is involved, oftentimes necessitating the use of different lubricants. In the frictional transmission there are no gears. The final drive or differential of both, however, involves the use of worm, spur, bevel or annular gears.

Transmission and rear axle lubrication is essentially a matter of combined gear and bearing lubrication, wherein the lubricant must serve a dual purpose. In the majority of tractors today the transmission is enclosed in an oil tight casing and bath lubrication is made possible. When the tractor is in motion, the service on both gears and bearings is very severe, so a lubricant must be used of just the right viscosity or body, to not only insure adequate penetration throughout all the bearings to furnish the requisite oil film with a minimum of internal friction, but also to protect the gear teeth from wear and to reduce noise during operation. In the geared transmission power is usually transmitted through two distinct gear reductions.

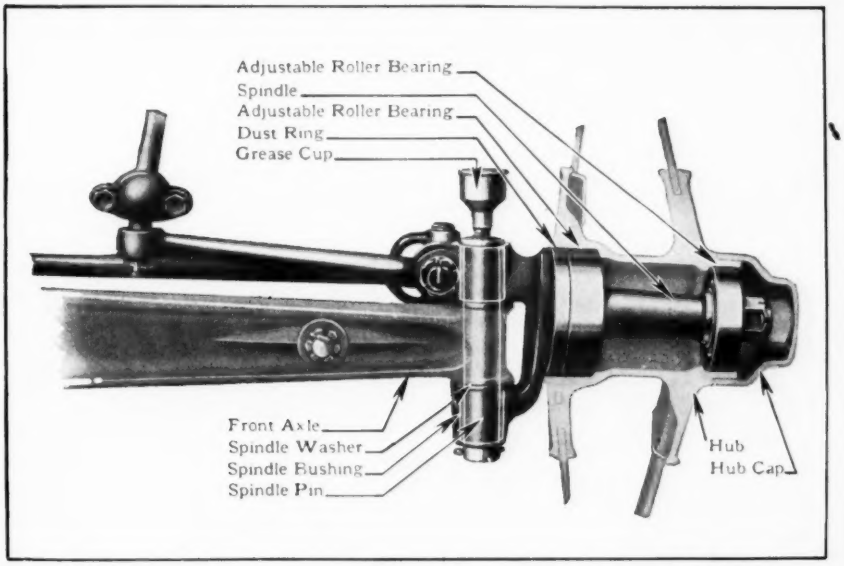
In view of the above, there is a certain amount of latitude relative to the viscosity or body of the lubricant, which should be used in a geared transmission. The controlling elements are the type of bearings and constructional conditions involved. Where installations are equipped with enclosed ball bearings on the gear shafts a straight mineral tractor oil, ranging in the neighborhood of from 500 to 750 seconds Saybolt at approximately 100 degrees F. will often give the best results. Others, wherein similar bearings are used, but so located that individual lubrication is possible, will call for grease or light oil lubrication of the bearings, the gears in turn being served by a straight mineral lubricant of approximately 120 seconds Saybolt viscosity at 210 degrees F. Still other installations, on account of design, wear or arrangement of gears, may require an even heavier lubricant of 200 seconds Saybolt at 210 degrees F.

Where using heavier gear lubricants, the gear case should never contain more than just enough to insure that the teeth of all gears on the lowest shaft of the transmission will dip in the lubricant. This will promote the most effective lubrication; any increase in the amount of lubricant in the case will impose a "drag" on the gears, especially in cold weather. Where slow motion is involved, however, certain authorities disregard "drag" and recommend that the level of the lubricant be raised until certain of the higher gears are submerged.

In this connection it is interesting to note that the builders of one type of extensively used tractor, wherein the transmission and rear axle are lubricated from the same oil bath located in the transmission case, recommend that the oil level be inspected twice a day, and that fresh oil be added when the machine is warm. When this latter is necessary the oil should be poured in to the level of the filler cap hole. Care should be taken to see that all parts have been reached by this oil before the cap is replaced.

The pour test of transmission gear lubricants is especially important when the tractor is to be used in cold weather. Even a properly filled gear case cannot insure us, if our gear lubricant has not a sufficiently low pour test to remain fluid under low temperature operation. In such an event the gears would channel through it, and any lubricant sticking to the side of the case would not flow readily back to the bottom. The evident precaution is to select a gear lubricant which will have a pour test at least as low as the average operating temperature which will be encountered in cold weather.

Where the transmission is not enclosed a lubricant must be used which will stick tenaciously to the gear teeth and not be thrown off by centrifugal force or affected by water. For this purpose a heavy bodied straight mineral gear compound of from 1,000 to 2,000 seconds Saybolt viscosity at 210 degrees F. should be used.



Courtesy of Ford Motor Company

Fig. 16—Details of the Fordson front wheel spindle. Note adjustable roller bearings, and oil-tight nature of the housing.

The Final Drive

While the final drive and differential may include spur gears, internal gears, chains, worm or bevel gears, according to the design of the machine, the spur gear predominates today.

In the majority of cases the chains or gears operate exposed, and it is necessary to use a gear lubricant of at least 2,000 seconds Saybolt viscosity to take up the shock and strain so often incurred, which would squeeze any lighter lubricant out from between the gear or sprocket teeth. Wear and deterioration will be bound to occur through the use of lighter oils or greases, as these would only drip off prematurely.

Courtesy of J. I. Case Threshing Machine Company

Fig. 17—The tractor fan also requires careful lubrication. Note gear drive, tightness of the gear case, and provision for grease lubrication of front bearing.

In driving chain lubrication the lubricant must again serve a dual purpose, i. e.:

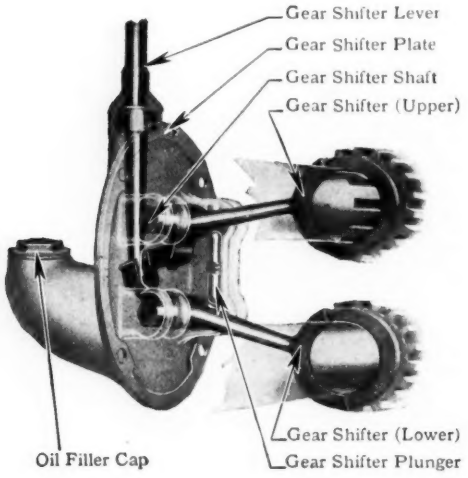
1. As a lubricant, and
2. As a protective agent.

Therefore, every care must be taken to thoroughly saturate the chain links and insure the lubricant penetrating to the innermost wearing parts. For this purpose a straight mineral lubricant having a viscosity of about 1,000 seconds Saybolt at 210 degrees F. is best suited. This should be applied hot, preferably by removing the chains and immersing them in a pail filled with the lubricant. They can then be hung up to cool and drain of excess lubricant.

MISCELLANEOUS LUBRICATION

The numerous other more or less external wearing elements on the average tractor which

require lubrication, include the fan bearing, axle bearings, steering mechanism joints and connections, and frequently the tractor link pins and rollers. With the exception of front and rear axles which are frequently equipped with ball or roller bearings, the above parts comprise



Courtesy of Ford Motor Company

Fig. 18—A tractor gear shifter assembly showing bearing details in phantom.

plain bearings, and require hand lubrication. In many cases this is attained by means of compression grease cups or a pressure gun. In others the oil can is still called into service, especially on the fan and commutator bearings.

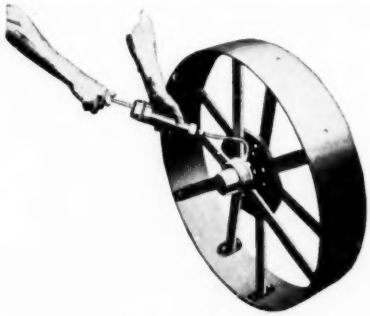
If the tractor as a whole is to function as an efficient unit, all these parts must of course be kept properly lubricated. While there is not the necessity for as exacting characteristics in the lubricants as is essential in the case of engine oils, etc., we should not go to the other extreme, in the belief that any old grease or oil will suffice. To best protect the parts in question in the face of almost sure prevalence of an excess of dust and dirt, lubricants of high initial purity must be used, and used in lubricating equipment which is capable as far as possible of preventing entry of foreign matter to the bearing surfaces.

Dependent upon the type of lubricators and design of bearings, compression cup grease, a light gear lubricant, engine oil or reclaimed oils will function effectively. Commutator and fan bearings for example, in many tractors require a light or a medium lubricating oil, applied by means of an oil can daily or at other periodic intervals according to the builder's recommendations. Steering mechanisms, front and rear axle bearings, and other such parts, in turn, are generally grease lubricated varying in frequency from once a day, once a week or less often, according to whether compression grease cups must be turned down or pressure grease gun lubrication is provided for by means of suitable fittings.

CONCLUSION

In view of the generally severe conditions under which the average gasoline or kerosene tractor will be required to function, it is apparent that every care must be given to the selection and usage of oils, greases and gear compounds. Practical experience dictates that for hand service in any field of operation of mechanical equipment, effective lubrication must exist if continuous and efficient duty is to be insured.

It will be well, therefore, to study the lubricating requirements of each particular tractor by an analysis of operating conditions, machine



Courtesy of Advance-Rumely Thresher Co., Inc.

Fig. 19—Greasing a tractor wheel bearing by means of an alemite pressure gun.

design, and builders' recommendations. Essential constructional details, and conditions of lubrication have been summarized in this article to lead to a better understanding of this problem of tractor lubrication in the interests of greater operating economy and increased production.

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